Effect of hydrogen peroxide bleaching on sulphonated jute-cotton blended fabric

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Received 25 April 2001; revised received and accepted 24 August 2001

Raw sulphonated jute, raw sulphonated jute-cotton and cotton fabrics were bleached under different conditions by varying pH, treatment time, temperature, hydrogen peroxide concentration and fabric-liquor ratio. Bleaching affected the brightness and breaking strength, and the optimum brightness (76.9%) and breaking strength (13.6 kgf) for the blended fabric were obtained with 6.5% hydrogen peroxide at pH 11, temperature 90°C, treatment time 100 min and fabric-liquor ratio 1:3. The thermal degradation of bleached sulphonated jute-cotton fabric was characterized by TG analysis and compared with the bleached cotton and bleached sulphonated jute fabrics. It has been observed that the thermal stability as well as brightness and breaking strength of the blended fabric largely depend on the amount of lignin and hemi-cellulose present in the fabric sample.

Keywords: Bleaching, Breaking strength, Thermal degradation

1 Introduction

Hydrogen peroxide is widely used in the textile industry as well as in the pulp and paper industry as a bleaching agent. Unlike chlorine and chlorite bleaching, hydrogen peroxide bleaching is free from chlorine atom and decreases pollution and improves the product quality. The use of hydrogen peroxide as a bleaching agent is limited because of its high cost. Depending on bleaching cost and product quality, hydrogen peroxide can partially replace bleaching powder, chlorite or hypochlorite in the bleaching of textiles.

Hydrogen peroxide bleaching plays a significant role in alkaline medium and this medium is essential for maximum bleaching efficiency. Presence of metal ions in bleaching operation leads to decomposition of peroxide and reduces its availability for bleaching. However, the stabilizing agents, including sodium silicate, magnesium salts and some complexing agents, are commonly used to control the decomposition of hydrogen peroxide. This may be explained by the buffer action and complex formation between these additives and active metal ion.

In the present study, hydrogen peroxide bleaching of sulphonated jute-cotton blended fabric has been carried out under different conditions by varying the treatment time, temperature, pH, hydrogen peroxide concentration and fabric-liquor ratio, and the optimum conditions worked out. An assessment of the brightness and breaking strength of bleached sulphonated jute-cotton blended fabric has been done and compared with that of bleached sulphonated jute and cotton fabrics. The thermal degradation of bleached sulphonated jute-cotton fabric has also been studied.

2 Materials and Methods

2.1 Materials

Sulphonated jute, sulphonated jute-cotton and cotton fabrics were used as the fabric samples. Hydrogen peroxide (BDH) and sodium silicate (BDH) used were of reagent grade. Lancophor BMB (brightening agent) and Sandopan DTC (wetting agent) were supplied by Sandoz Chemical Ltd.

2.2 Production of Fabric

Jute fibre was sulphonated in a digester with 15% sodium sulphite, 4% soda ash and 0.2% ethylenediamine at 160°C for 3 h, keeping the fabric-liquor ratio at 1:5 (ref. 8). Sulphonated jute fibre was blended with 40% cotton for production of plain woven (60 x 60) fabric.

2.3 Bleaching of Fabrics

Sulphonated jute, sulphonated jute-cotton and cotton fabrics were bleached by hydrogen peroxide in a high-pressure rapid lab-deep machine. The different bleaching variables studied were hydrogen peroxyd

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Hydrogen peroxide concentration (1–9% on weight of fabric), temperature (40–100 °C), treatment time (40–120 min), pH (5–13) and fabric-liquor ratio (1:2–8). In addition to hydrogen peroxide, some chemicals, viz. soda ash (3.5%), sodium silicate (4.0%), wetting agent Sandopan DTC (1.0%) and brightening agent Lancophor BMB (0.3%) were added to get better results. After bleaching, the samples were washed thoroughly with distilled water.

2.4 Measurement of Brightness
The brightness of all the bleached fabric samples was measured by using Photovolt Reflectometer (Model No. 577)11.

2.5 Measurement of Breaking Strength
The breaking strength of all the bleached fabric samples was measured by the tensile strength tester (Torsese’s Schopper Type -OS-100)12.

2.6 Thermogravimetric Analysis
The thermogravimetric analysis (TGA) of all the bleached fabric samples was done by using Mettle TG-50 (Shimadzu). The heating rate was kept at 10 °C /min throughout the study. The measurement was done under a constant flow rate (20 ml/min) of nitrogen13.

3 Results and Discussion
3.1 Effect of Hydrogen Peroxide
The effect of hydrogen peroxide on brightness and breaking strength of sulphonated jute, sulphonated jute-cotton and cotton fabrics is shown in Fig. 1. It is seen from the figure that the breaking strength decreases with the increase in hydrogen peroxide concentration, but the brightness increases with the increase in peroxide concentration from 1.0% to 6.5% (based on weight of fabric). However, further increase in peroxide concentration results in a slight increase in fabric brightness. From the result, it is clear that the increase in hydrogen peroxide charge lowers the initial pH which is stoichiometrically unfavourable to bleaching. Therefore, low peroxide charge has a pronounced and favourable effect on the stoichiometry. An increase in hydrogen peroxide charge results not only in an increase in peroxide consumption but also in some cases produces a greater reduction in light absorption coefficient due to the oxidation of cellulose chains14. The brightness percentage of the bleached blended fabric is 71.2% at 6.5% hydrogen peroxide. This brightness is 4.5% lower than that of bleached cotton fabric and 10.2% higher than that of bleached sulphonated jute fabric. The breaking strength of bleached blended fabric is 9.3 kgf.

3.2 Effect of Treatment Time and Temperature
The effect of treatment time and temperature on the breaking strength and brightness of bleached sulphonated jute, sulphonated jute-cotton and cotton fabrics is similar to that of hydrogen peroxide. Breaking strength of these fabrics decreases with the increase in reaction time and temperature. On the other hand, the brightness increases with the increase in temperature up to 90 °C and then it decreases with further increase in temperature. Bleaching temperature of more than 90 °C produces greater breakdown of hydrogen peroxide and consequently it appears to be decomposed without a bleaching effect. Again, the high temperature is not desired since it creates the risk of whiteness reversion15. At high temperature and long duration, some bonds break down and ultimately the breaking strength of the fabric decreases. Again, the brightness increases with the increase in treatment time up to 100 min and then it increases slowly with the further increase in treatment time.

3.3 Effect of pH
The effect of pH on the brightness and breaking strength of sulphonated jute, sulphonated jute-cotton
and cotton fabrics is shown in Fig. 2. It is observed that the breaking strength and brightness increase with the increase in pH up to 11 and then decrease with further increase in pH. Hydrogen peroxide is stable at high pH which is effective in liberating perhydroxy ions (HOO⁻) which are responsible for bleaching. Decreasing the pH in the bleaching medium causes the peroxide to become unstable. In this case, the perhydroxy ions are used to form water and liberate oxygen molecule. The liberated molecular oxygen, however, has no bleaching action and causes a loss of bleaching power. Therefore, pH 11 is found to be optimum for obtaining good whiteness and maximum breaking strength by minimizing hydrogen peroxide decomposition. The breaking strength and brightness of the blended fabric obtained at pH 11 by the bleaching operation are 13.2 kg/f and 73.4% respectively.

![Graph showing the effect of pH on brightness and breaking strength of bleached sulphonated jute, sulphonated jute-cotton and cotton fabrics](image)

**Fig. 2**—Effect of pH on brightness and breaking strength of bleached sulphonated jute, sulphonated jute-cotton and cotton fabrics (Brightness: (Ø) jute fabric, (O) blended fabric, (Δ) cotton fabric. Breaking strength: (●) jute fabric, (●) blended fabric, (Δ) cotton fabric) 

### 3.4 Effect of Fabric-Liquor Ratio

The breaking strength and brightness of bleached sulphonated jute, sulphonated jute-cotton and cotton fabrics increase with the increase in fabric-liquor ratio and the nature of the curves is similar to that of pH. The maximum brightness of these three fabrics observed are 68.5, 76.0 and 80.6% respectively at a fabric-liquor ratio of 1:3 and these decrease with further increase in fabric-liquor ratio. A decrease or increase in the fabric-liquor ratio gives an increased or decreased peroxide concentration at constant peroxide charges. Increase in fabric-liquor ratio beyond 1:3 does not improve the bleaching response of hydrogen peroxide. The presence of perhydroxy radicals, that are produced by peroxide decomposition, may be responsible for the bleaching effect. As the liquor ratio decreases, the perhydroxy radicals are more likely to be generated close to a fibre and so be more likely to effect the colour of the fabrics.

It is observed from the experiment that the optimal brightness and breaking strength attained by the bleached blended fabric are 76.9% and 13.6 kg/f respectively at 6.5% hydrogen peroxide (based on weight of fabric), pH 11, temperature 90°C, treatment time 100 min and fabric-liquor ratio 1:3. The brightness of bleached blended fabric is lower than that of bleached cotton fabric and higher than that of bleached sulphonated jute fabric when the reaction conditions are same. A similar trend is observed in the case of breaking strength. The breaking strength of bleached sulphonated jute fabric is higher than that of bleached blended fabric.

### 3.5 Thermogravimetric Analysis

The thermal behaviour of bleached sulphonated jute, sulphonated jute-cotton and cotton fabrics was examined by a study of their TGA thermograms and the results are given in Table 1. It is observed from Table 1 that the loss in weight up to 289°C is 11.8 - 12.9% which is due to the desorption of adsorbed water and volatile matters. The actual pyrolysis starts at around 285°C and ends at around 395°C. The loss in

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Initial weight loss region °C</th>
<th>Weight loss %</th>
<th>Actual pyrolysis region  °C</th>
<th>Weight loss at the end of pyrolysis %</th>
<th>Char decomposition region  °C</th>
<th>Decomposed char %</th>
<th>Residual char %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute</td>
<td>25-284</td>
<td>12.9</td>
<td>284-344</td>
<td>54.2</td>
<td>344-600</td>
<td>16.4</td>
<td>17.5</td>
</tr>
<tr>
<td>Jute-cotton blended</td>
<td>25-289</td>
<td>12.5</td>
<td>289-394</td>
<td>63.9</td>
<td>394-600</td>
<td>11.2</td>
<td>13.4</td>
</tr>
<tr>
<td>Cotton</td>
<td>25-284</td>
<td>11.8</td>
<td>284-386</td>
<td>68.1</td>
<td>386-600</td>
<td>8.3</td>
<td>11.8</td>
</tr>
</tbody>
</table>
weight of the blended fabric at 394 °C is 62.90%. The char residue of blended fabric at 600 °C is comparatively higher than that of bleached cotton fabric and lower than that of sulphonated jute fabric. The char residue is, therefore, highly related to the amount of lignin present in the sample. This lignin affects the overall TGA of blended fabric. The strength of jute fabric as well as of blended fabric largely depends on the amount of lignin present in jute sample. The removal of lignin also affects the brightness.

4 Conclusions

Brightness increases with the increase in bleaching variables up to a certain value and then more or less decreases. On the other hand, the breaking strength decrease with the increase in the value of bleaching parameters, except pH and fibre-liquor ratio. The pH is the important factor which critically affects both breaking strength and brightness. Thermogravimetric analysis shows that both breaking strength and brightness depend largely on the amount of lignin and hemicellulose present.

References